Planetary Instrument Concepts For The Advancement Of Solar System Observations

The Development of A Double Hemispherical Probe for The Advancement of Space Plasma Measurements

Completed Technology Project (2017 - 2020)

Project Introduction

Science goals and objectives. Langmuir probes have been widely used onboard spacecraft (SC) for characterizing the space plasma density, temperature and SC potential using their current-voltage (I-V) curves. However, plasma environments in space are complex. When they interact with SC and in-situ Langmuir probes, localized plasmas will be generated around the probes and influence their measurements. These localized plasma environments are often anisotropic/inhomogeneous. We propose a novel Double Hemispherical Probe (DHP), which is an upgrade from a traditional single spherical probe (SSP). The DHP is composed of two identical hemispheres that are electrically insulated back to back and swept with the same potential biases simultaneously. When using the total current from two hemispheres, the DHP works identical as the SSP. However, the information derived from the differences between the I-V curves of the two hemispheres will greatly enhance the capability and accuracy for the ambient plasma characterization. The DHP has advantage over the traditional single Langmuir probes in the following anisotropic/inhomogeneous scenarios: 1) The probe may be immersed in the SC sheath due to its limited boom length. The DHP is able to identify and mitigate these effects on the probe measurements; 2) The photo- and/or secondary electron emission from the SC and probe itself are usually a significant contamination to the probe measurements, which can be better characterized using the DHP and removed from its I-V curves; 3) Ions generally have a drift speed relative to the SC. Using the developed Mach probe theories, the DHP is able to more accurately characterize the flowing ions; 4) When the SC zooms in dust-rich plasma environments, dust impact on the probe and SC will create localized plasma sources. The DHP is more capable to analyze and minimize the dust impact effects on the probe measurements. In addition, new coating materials for the probe surface will be validated to mitigate the surface oxidation problem in an oxygen-rich plasma environment. In summary, the objectives of our research are: 1) To enhance the capability and accuracy of the characterization of space plasmas by developing a novel Double Hemispherical Probe; 2) To develop new coating materials for mitigating the probe surface oxidation problem. Our science goal is to improve the understanding of space plasmas in harsh environments, including low-density plasmas, high surface-emission environments, dust-rich and oxygen-rich plasmas. Methodology. We will build a prototype DHP, which mechanical design and electric circuitries take heritage from the current mature SSP technologies. The prototype DHP will be examined and studied using existing small-scale plasma chambers, the Colorado Solar Wind Experiment device and the dust accelerator facility at our NASA SSERVI/IMPACT laboratory at the University of Colorado-Boulder. The data analysis methods will be developed and validated with the experimental results. The new coating materials for the probe surface will be validated using oxygen plasmas and coated on the prototype probe. Relevance to this program. The proposed DHP development will significantly improve the capability and accuracy for characterizing space and planetary plasma

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Organizational Responsibility

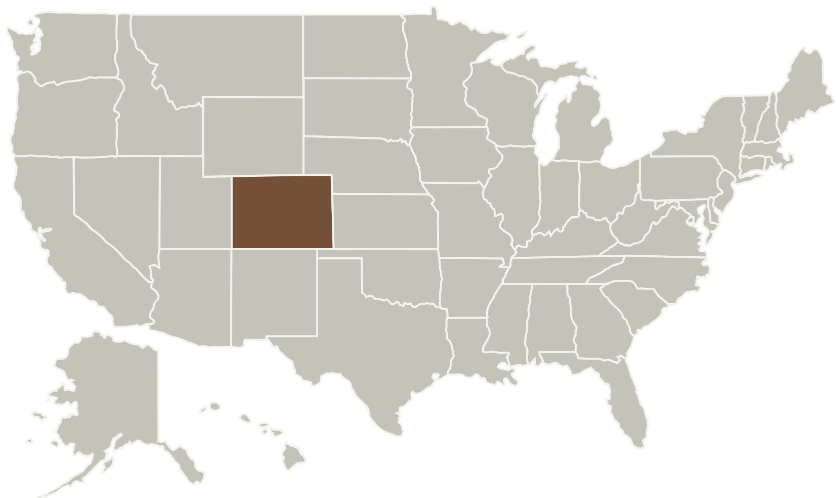
Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Planetary Instrument Concepts for the Advancement of Solar System Observations environments. The proposed instrument addresses several NASA's planetary science strategic goals and the goals in the decadal survey in 2013-2022. The entry level of the DHP development is between TRL 2 and 3, and the exit level is TRL 5 at the completion of the proposed technology. The proposed instrument development is highly relevant to the scope of this program and several potential NASA missions defined in the decadal survey.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of Colorado Boulder	Supporting Organization	Academia	Boulder, Colorado

Primary U.S. Work Locations
Colorado

Project Management

Program Director:

Carolyn R Mercer

Program Manager:

Haris Riris

Principal Investigator:

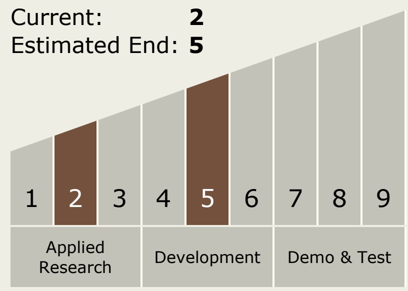
Xu Wang

Co-Investigators:

Robert E Ergun
Jan-erik Wahlund
Hsiang-wen Hsu
Karen J Springfield
Mihaly Horanyi
Ralf Srama

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **5**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  └─ TX08.3 In-Situ Instruments and Sensors

Continued on following page.

Technology Areas *(cont.)*

└ TX08.3.4 Environment Sensors

Target Destination

Others Inside the Solar System